

## CLAIMS

1. A microfilter element for removing impurities in the range of about 0.5  $\mu\text{m}$  to about 25.0  $\mu\text{m}$  from aviation fuel, said element comprising a cylindrical filter media and an exoskeleton for the filter media;
- 5 the filter media including a filtration layer sandwiched between inner and outer layers;
- the filtration layer being made of fiberglass and/or at least one polymer;
- the inner and outer layers being made of a non-woven polymer;
- the layers of the filter media being folded into a plurality of longitudinally-
- 10 extending pleats with a density of about 8 or more pleats per inner diameter inch;
- the exoskeleton comprising a support screen bonded to peaks of the pleats to support the pleats in an appropriately spaced and non-collapsed condition;
- 15 the support screen providing at least 50% open flow area and a tight array of attachment points so that the filter media is sufficiently supported without having cellulose-fiber and/or woven-mesh endoskeleton support layers.
2. A microfilter element as set forth in claim 1, wherein the layers of the filter media consist essentially of the filtration layer, the inner layer, and the
- 20 outer layer.
3. A microfilter element as set forth in claim 2, wherein the filtration layer has a thickness of about 0.015 inch to about 0.035 inch and wherein the inner and outer layers are each have a thickness of about 0.008 to about 0.017 inch.
- 25 4. A microfilter element as set forth in claim 2, wherein the support screen comprises a thermal-bondable mesh having cords which form a grid of approximately about 0.060 inch to about 0.150 inch by 0.060 inch to about 0.150 inch openings which are aligned with a longitudinal axis of the filter media.

5. A microfilter element as set forth in claim 4, wherein the support screen is bonded to the radially outer peaks of the filter media.

5 6. A microfilter element as set forth in claim 4, wherein the plurality of longitudinally-extending pleats include two end pleats joined together at a side seam and wherein the side seam comprises an adhesive bead which encapsulates all of the layers in distal ends of the end pleats.

7. A microfilter element as set forth in claim 1, wherein the plurality of  
10 longitudinally-extending pleats include two end pleats joined together at a side seam and wherein the side seam comprises an adhesive bead which encapsulates all of the layers in distal ends of the end pleats.

8. A microfilter element as set forth in claim 1, further comprising a center tube positioned within the cylindrical filter media.

15 9. A microfilter element as set forth in claim 1, further comprising end caps attached to opposite axial ends of the filter media.

10. A filter element comprising a cylindrical filter media and an exoskeleton support structure surrounding the filter media;  
the filter media being formed from only cellulose-fiber-free and woven-  
20 mesh-free layers including a filtration layer sandwiched between inner and outer layers;

the layers of the filter media being folded into a plurality of longitudinally-extending pleats having radially-inner peaks defining an inner diameter, radially-outer peaks defining an outer diameter, and side walls extending therebetween;  
25 the exoskeleton support structure being attached to the radially-outer peaks and/or radially-inner peaks in such a manner that the filter media is sufficiently supported without cellulose-fiber and/or woven-mesh endoskeleton support layers.

11. A filter element as set forth in claim 10, wherein the layers of the filter media consist essentially of the filtration layer, the inner layer, and the outer layer.

12. A filter element as set forth in claim 10, wherein the filtration layer is made of at least one of fiberglass, nylon, polyamide, polyester, polyethylene, polypropylene, or mixtures thereof.

13. A filter element as set forth in claim 10, wherein the inner and outer layers each have a thickness of less than about 0.030 inches.

14. A filter element as set forth in claim 10, wherein the inner and outer layers are each made of a non-woven polymer.

15. A filter element as set forth in claim 10, wherein the layers of the filter media consist essentially of the filtration layer, the inner layer, and the outer layer, wherein the filtration layer is made of at least one of fiberglass, nylon, polyamide, polyester, polyethylene, polypropylene, or mixtures thereof, and wherein the inner and outer layers each have at thickness less than about 0.030 inches and are made of a non-woven polymer.

16. A filter element as set forth in claim 15, wherein the filter media has a pleat density of about 8 or more pleats per inner diameter inch.

17. A filter element as set forth in claim 10, wherein the filter media has a pleat density of about 8 or more pleats per inner diameter inch.

18. A filter element comprising a cylindrical filter media and an exoskeleton support structure supporting the filter media;  
the filter media being formed from a plurality of layers folded into a plurality of longitudinally-extending pleats having radially-inner peaks defining an

inner diameter, radially-outer peaks defining an outer diameter, and side walls extending therebetween;

the filter media having a pleat density of about 8 or more pleats per inner diameter inch.

- 5           19. A filter element as set forth in claim 18, wherein the filter media has a pleat density of about 12 or more pleats per inner diameter inch.

20. A cylindrical filter media comprising a plurality of longitudinally extending pleats and a side seam;

- 10           the plurality of pleats including two end pleats each including a filtration layer, an inner layer and an outer layer;

the two end pleats each having a distal end, a radially-inner peak, an endmost sidewall extending from the distal end to the radially-inner peak, and a radially outer peak;

- 15           the sidewalls being positioned adjacent each other and the distal ends being positioned radially outward relative to the radially-inward peaks; and  
the side seam comprising an adhesive bead which encapsulates all of the layers in the distal ends of the end pleats.

21. A cylindrical filter media as set forth in claim 20, wherein the  
20           adhesive bead extends radially inward between the respective sidewalls of the end pleats.

22. A cylindrical filter media as set forth in claim 21, wherein the adhesive bead extends circumferentially between the radially outward peaks of the two end pleats.

- 25           23. A filter element comprising the filter media of claim 20 and an exoskeleton support structure surrounding the filter media and attached to radially outward peaks of each of the pleats.

24. A method of making the filter media of claim 20, comprising the steps of:

compiling the filtration layer, the inner layer and the outer layer;

folding the compiled layers to form a sheet with the plurality of pleats;

5 placing the end pleats in a fixture which positions them so that outwardly opening flow spaces are available between the adjacent sidewalls and the radially-outer peaks; and

applying a stream of adhesive over the open spaces to form the adhesive bead.

10 25. A cylindrical filter media comprising a plurality of longitudinally extending pleats and a side seam;

the plurality of pleats including two end pleats each having a distal end, a radially-inner peak, an endmost sidewall extending from the distal end to the radially-inner peak, and a radially outer peak;

15 the sidewalls being positioned adjacent each other and the distal ends being positioned radially outward relative to the radially-inward peaks; and

the side seam comprising an adhesive bead which extends radially inward between the endmost sidewalls of the end pleats and circumferentially between endmost radially outward peaks of the two end pleats.

20 26. A filter element comprising a cylindrical filter media and an exoskeleton support structure for the filter media;

the cylindrical filter media comprising a plurality of longitudinally-extending pleats having radially-inner peaks defining an inner diameter, radially-outer peaks defining an outer diameter, and side walls extending therebetween;

25 the exoskeleton support structure comprising a support screen having a first set of cords extending in a first direction, a second set of cords extending in a second direction and intersecting with the first set of cords, and openings defined therebetween;

the cords being attached to each of the radially-outer peaks or each of the radially-inner peaks thereby exoskeletonally supporting the pleats in an appropriately spaced and non-collapsed condition;

adjacent cords in the first set being separated from each other by a distance  $d_1$ , adjacent cords in the second set being separated from each other by a distance  $d_2$ , and adjacent radially-outer peaks being separated from each other by a distance  $d_{\text{pleat}}$ ; and

the distance  $d_1$  between the first set of cords being about half to about twice the distance  $d_{\text{pleat}}$  between adjacent radially-outer peaks.

27. A filter element as set forth in claim 26, wherein the first set of cords extend substantially parallel with the longitudinal dimension of the pleated media and the second set of cords extend substantially perpendicular thereto.

28. A filter element as set forth in claim 27, wherein the distances  $d_1$  and  $d_2$  are approximately equal whereby the openings are square in shape.

29. A filter element as set forth in claim 26, wherein the distances  $d_1$  and  $d_2$  are approximately equal whereby the openings are square in shape.

30. A filter element as set forth in claim 26, wherein the distance  $d_1$  is between about .05 inch and .15 inch and wherein the distance  $d_2$  is between half to about twice the distance  $d_1$ .

31. A filter element as set forth in claim 26, wherein the second set of cords provide about 7 to about 20 attachment points per axial inch of each of the peaks.

32. A filter element as set forth in claim 26, wherein the support screen is non-adhesively attached to the peaks.

33. A filter element as set forth in claim 32, wherein the support screen is thermally bonded to the peaks.

34. A filter element as set forth in claim 33, wherein the support screen is made of a PVC coated fiberglass mesh.

5 35. A filter element as set forth in claim 26, wherein the support screen comprises a sheet of mesh material having lateral edges joined together at a side seam which extends substantially the length of the longitudinal axis of the filter media.

36. A filter element as set forth in claim 35, wherein the lateral edges  
10 overlap and are thermally bonded together.

37. A filter element as set forth in claim 26, wherein the cords are attached to each of the radially-outer peaks.

38. A filter element as set forth in claim 26, wherein the cords are attached to each of the radially-inner peaks.

15 39. A filter element comprising a cylindrical filter media and an exoskeleton support screen for the filter media;  
the cylindrical filter media comprising a plurality of longitudinally-extending pleats having radially-inner peaks defining an inner diameter, radially-outer peaks defining an outer diameter, and side walls extending therebetween;  
20 the support screen comprising a sheet of screen material having a width approximately equal to the axial dimension of the filter media and a length approximately equal to the circumferential dimension of the filter media plus a seam allowance;  
the sheet of screen material having lateral edges joined together at a side  
25 seam; and

the support screen being thermally bonded to each of the radially-outer peaks or each of the radially-inner peaks thereby exoskeletonally supporting the pleats in a spaced and non-collapsed condition.

5           40.     A filter element as set forth in claim 39, wherein the side seam extends substantially parallel to the longitudinal axis of the filter media;

          41.     A filter element as set forth in claim 39, wherein the lateral edges overlap and are thermally bonded together.

          42.     A filter element as set forth in claim 41, wherein the support screen  
10 is made of a PVC coated fiberglass mesh.

          43.     A filter element as set forth in claim 39, wherein the support screen is made of a PVC coated fiberglass mesh.

          44.     A filter element as set forth in claim 39, wherein the sheet of screen material is rectangular in shape.

15           45.     A filter element as set forth in claim 39, wherein the support screen is thermally bonded to each of the radially-outer peaks.

          46.     A filter element as set forth in claim 39, wherein the support screen is thermally bonded to each of the radially-inner peaks.

          47.     A method of making the filter element of claim 39, comprising the  
20 steps of:  
  
          thermally bonding at least a portion of the screen material to the peaks of the pleats prior to the filter media being formed in a cylindrical shape; and  
          shaping the filter media into a cylinder.



48. A method as set forth in claim 47, further comprising the step of forming the side seam by overlapping end sections of the screen material over each other and thermally bonding the overlapped end sections, said forming steps being performed after said shaping step.

5 49. A method as set forth in claim 47, wherein the thermally bonding step comprises:

positioning the pleated but not-yet-cylindrically-shaped filter media in a fixture block having a pocket with a width corresponding to an outside circumference of the filter media in its desired cylindrical shape with its radially inward peaks positioned at the bottom of the pocket;

10 positioning end pleats of the filter media on lateral edges around the pocket; and

ironing a portion of the sheet material to the pleats contained within the pocket.

15 50. A method as set forth in claim 49, wherein said ironing step comprises ironing a central portion of the sheet material to the pleats contained within the pocket but not yet thermally bonding lateral end sections of the sheet material to the filter media.

20 51. A method as set forth in claim 50, further comprising the steps of: removing the filter media from the pocket;

joining the end pleats to form the filter media into the desired cylindrical shape; and

overlapping and thermally bonding together the lateral end sections of the screen material.

25 52. A coalescer element for removing free water and particulates from aviation fuel, said element comprising a cylindrical media and an exoskeleton for the media;

the exoskeleton comprising a support screen bonded to each of the radially inward peaks of the pleats to support the pleats in an appropriately spaced and non-collapsed condition; and

- 5 the support screen providing at least 50% open flow area and a tight array of attachment points so that the filter media is sufficiently supported without a central support tube.

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